GENETIC STUDIES ON SOME QUANTITATIVE TRAITS IN PEA 1. INHERITANCE OF VEGETATIVE CHARACTERS, YIELD AND ITS COMPONENTS

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(Manuscript received 5 July 2015)

Abstract

This study was conducted in Horticulture Research Institute during the period from 2012 to 2015 to study the inheritance of some garden pea economic characters, *viz.*, plant length, number of branches/plant, green pod yield/plant, number of pods/plant and pod weight. Four garden pea cvs., *viz,* Master, Perfection 57, Prism and Twin were chosen to produce 3 crosses and their reciprocals. Results showed that maternal effect was absence in all studied characters. Over dominance was detected for high number of branches/plant, high green pod yield/plant and high number of pods/plant in all studied crosses. Over dominance or complete dominance was detected for high plant length. High pod weight was dominant in some studied crosses and the opposite was found in the others. Positive heterosis over the better parent was found in all studied crosses for plant length, number of branches/plant, green pod yield/plant and number of pods/plant traits, however, negative heterosis was detected in all studied crosses for pod weight. Minimum number of estimated genes was one for plant length trait, 1-9 for number of branches/plant, 2-3 for green yield/plant, 3-6 for number of pods/plant and pod weight. Broad sense heritability estimates were 79.49%-89.65% for plant length, 75.14%-83.69% for number of branches/plant, 79.44%-90.81% for green yield/plant, 77.30%-79.91% for number of pods/plant, while it was 30.75%-53.43% for pod weight.

Key words: *Pisum sativum*, Dominance, Heterosis, Number of genes, Heritability, Plant length, Green yield, Yield components.

INTRODUCTION

Garden pea, *Pisum sativum* L., is a short cash vegetable crop during winter season in Egypt. The improvement of pea yield depends upon a better understanding of the type of gene action controlling yield and its attributed components. Recently there are intensive efforts for improvement of pea productivity in Egypt through breeding procedures depending mainly on the presence of genetic differences that permits effective selection. Hybridization is considered main effective factor for inducing variability.

Non-significant differences were observed between F_1's and their reciprocals in peas for plant length trait in all studied crosses indicating absence of maternal effect (Noser, 2002 and Hamed, 2005). Noser (2002), Hamed (2005) and Sood and Kalia (2006) found that dominance of plant length was variable according to the parental lines used. Heterosis over the taller parent ranged from 0.98% to 83.28% as estimated by Noser (2002). Meanwhile, Hamed (2005) found negative heterosis in some pea crosses and positive heterosis in others. Noser (2002) found that plant length of peas was governed by 1-5 genes, while, Hamed (2005) estimated it as 1-3 pairs of genes. Broad sense heritability (BSH) of plant length of pea was high in the broad sense (Bora *et al.*, 2009, Kumari *et al.*, 2009 and Galal, 2014) which suggested that this trait would respond to selection. Also, Noser (2002), Hamed (2005) and Zayed *et al.* (2005) estimated BSH as from 16.19% to 76.60%, from 54.6% to 74.2%, and 96.6%, respectively.

No-significant differences were obtained between F_1's and their reciprocals for number of branches/plant trait in all studied crosses indicating absence of maternal effect (Noser, 2002). Presence of over dominance and complete dominance towards the highest parent for this trait was indicated by Noser (2002) and Singh and Mishra (2002) on pea. All the studied crosses exhibited positive heterosis over better parent ranging from 13.59% to 36.59% (Noser, 2002). Minimum number of genes (MNG) controlling number of branches/plant trait was estimated as 1-3 pairs (Noser, 2002), while, Singh and Mishra (2002) estimated it as one pair of genes. Gupta *et al.* (2006) and Singh (2010) on pea estimated high values of heritability in the broad sense for this trait, meanwhile, El-Dakkak *et al.* (2014) found moderate to high heritability for this trait.

Maternal effect was remarked for green pod yield/plant trait only in 2 out of 6 crosses of garden peas (Noser, 2002). High positive P values indicated over dominance and partial dominance towards the high yielding parent were estimated (Sood and Kalia, 2006). Meanwhile, Noser (2002) found different types of dominance for this trait. Noser (2002) observed significant positive heterosis of pod green yield/plant in all studied crosses estimating as 6.54% to 74.93% except in one cross which exhibited negative heterosis. Minimum number of genes controlling green pod yield/plant trait was estimated as a single pair of genes in all crosses (Noser, 2002). High BSH estimates were observed for green pod yield trait (Bora *et al.,* 2009, Choudhary *et al.,* 2010, Singh, 2010 and El-Dakkak *et al.*, 2014). Zayed *et al.* (2005) estimated BSH as 66.4%.

Noser (2002) indicated that maternal effect was not observed for number of pods/plant trait in any of the studied crosses. Meanwhile, Hamed (2005) found that maternal effect existed for this trait only in one out of the four studied crosses. Over dominance for number of pods per plant was reported by Sood and Kalia (2006).

Noser (2002) found over dominance of the highest parent in three crosses and complete dominance of the highest parent in three others. Hamed (2005) observed complete dominance of the highest parent in 3 out of 4 crosses and complete dominance of the lowest number of pods/plant in one cross. Positive heterosis over the better parent for this trait ranged from 6.44% to 104.21% (Noser, 2002). On the contrary, Hamed (2005) estimated negative heterosis values ranged from -32.7% to -2.9% in all evaluated crosses. Minimum number of genes controlling number of pods/plant was one pair of genes in all studied crosses (Noser, 2002 and Singh and Mishra, 2002). Meanwhile, Hamed (2005) estimated it as 1-7 pairs of genes. Kumari *et al*. (2009), Choudhary *et al*. (2010) and Singh *et al.* (2012) estimated high values of heritability in the broad sense indicating good scope for selection for number of pods/plant trait. In the same direction, Galal (2014) on pea estimated BSH for number of pods/plant trait as 90.0%-91.5%. While, it was moderate to high and ranged from 54.9% to 86.0%, from 37.9% to 78.8%, 86.6% and from 32.12% to 86.61% as estimated by Noser (2002), Hamed (2005), Zayed *et al*. (2005) and El-Dakkak *et al*. (2014), respectively.

Non-significant differences were observed between F_1's and their reciprocals for pod weight character indicating no maternal effect (Hamed, 2005). Hamed (2005) found partial dominance towards the lowest parent for this character. Negative heterosis values for this trait were estimated as -24.0% to -26.9% (Hamed, 2005). Minimum number of genes controlling pod weight was estimated as 3-5 pairs (Hamed, 2005). High estimates of BSH were obtained for pod weight by Bora *et al.* (2009), meanwhile, Gupta *et al.* (2006) and Galal (2014) estimated it as 74.65 and 75.0% to 80.0%, respectively. On the contrary, Hamed (2005) found low BSH being 17.6% to 22.6% for this trait.

The main objective of the present investigation was to study the inheritance of some economic characters of garden pea to produce and select new lines with high yielding ability which can be included in subsequent breeding programs.

MATERIALS AND METHODS

This study was conducted during the period from 2012 to 2015. Production and evaluation of genetic populations were carried out in the open field at Kaha Vegetable Research Farm, Kalubia Governorate, Egypt. Four garden pea cvs., *viz,* Master, Perfection 57, Prism and Twin were chosen for genetic studies based on their performance as shown in Table 1.

Table 1. Description of studied cultivars.

Cultivar	Stem length	Leaf type	No. of days from sowing to flowering	No. of nods to first pod	No. of pods/node	Pod color	Seed size
Master	Short	Conventional	44	7-8	1-2	Green	Medium
Perfection 57	Medium	Leafless	55	13-14	2-3	Green	Medium
Prism	Short	Leafless	60	13-14	2	Dark green	Medium
Twin	Medium	Conventional	60	13-14	2-3	Green	Small

Seeds of these cultivars were sown in the open field at Kaha on mid October, 2012. Three crosses, *viz.,* Master × Perfection 57, Master × Prism and Master × Twin and their reciprocals were produced. Seeds of the straight F_1 crosses were sown on mid October, 2013. Flowers on plants were left for selfing to produce F_2 seeds. In the same time, production of F_1 seeds was completed.

Evaluation of genetic populations was carried out at Kaha. Seeds of parents, F_1, F_1r and F_2 populations of each of the three crosses were sown on mid October, 2014 in a randomized complete block design with three replicates. Each replicate consisted of one row for every non-segregating population, *i.e.,* parents, F_1 and their reciprocals and three rows for each F_2. Each row was 3.0 m long and 0.7 m wide. Individual seeds were sown 15 cm apart. Cultural practices such as irrigation, chemical fertilization and disease and insect control were practiced as commonly followed in this district.

Data were recorded on individual plants for the different populations in each cross for plant length, number of branches/plant, green pod yield/plant, number of pods/plant and pod weight. Characters were studied only in the crosses which their parents were significantly different in such characters.

Data were recorded as follow:

Plant length was measured at the end of the harvesting season from the surface of the soil to the highest point of the stem in cm. Number of branches/plant was measured as the main branches/plant. Green pod yield/plant was measured as the weight of all harvested pods. Number of pods/plant. Pod weight was estimated as the mean of five pods/plant in g.

Genetic parameters estimated

Maternal effect was estimated by measuring the significance of difference between each F_1 mean and it's reciprocal by the (t) test.

Potence ratio, *i.e.,* the relative potency of gene set (P) was used to determine the direction of dominance according to the following formula (Smith, 1952):

$$P = \frac{\overline{F_1} - MP}{½ (\overline{P_2} - \overline{P_1})}$$

Where: $\overline{F_1}$ = First generation mean, $\overline{P_1}$ = Mean of the lower parent, $\overline{P_2}$ = Mean of the higher parent, and MP = Mid parent value = ½ $(\overline{P_1} + \overline{P_2})$. The absence of dominance was assumed when the difference between the parents was significant and F_1- MP was not significant. Complete dominance was assumed when potence ratio equaled to or did not significantly differ from ± 1.0. Meanwhile, partial dominance was considered when potence ratio was between + 1.0 and – 1.0, but was not equal to zero. Over dominance (Heterosis) was assumed when potence ratio exceeded ± 1.0.

Heterosis was calculated on better parent basis using the following formula:

$$\text{Better-parent heterosis} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100 \quad \text{(Sinha and Khanna, 1975)}$$

Where: $\overline{F_1}$ = Mean of the first hybrid generation and $\overline{BP}$ = Mean of the better parent.

The minimum number of genes controlling the character in each cross was calculated using Wright formula as follows:

$$N = \frac{0.25\,(0.75 - h + h^2)\,D^2}{V_{F2} - V_{F1}} \quad \text{(Burton, 1951)}$$

where:

$$h = \frac{\overline{F_1} - \overline{P_1}}{\overline{P_2} - \overline{P_1}}$$

N = The minimum number of genes controlling the character in each cross, D =The difference between the observed mean of female and male parents, P_1, P_2 and F_1 are means of the parents and F_1 populations, respectively, and V_{F1} and V_{F2} = Variances of the F_1 and F_2 populations, respectively.

Broad senses heritability (BSH) was calculated using the equation:

$$BSH = \frac{V_G}{V_P} \times 100 \quad \text{(Allard, 1960)}$$

where: V_G = Genetic variance which was calculated by subtracting the environmental variance (V_E) from (V_P), V_P = Phenotypic variance = V_{F2}, and V_E = Environmental variance which was calculated as the geometric mean of variances of the non-segregating populations, *i.e.* parents and F_1.

RESULTS AND DISCUSSION

Plant length

Data obtained regarding plant length of parental, F_1, F_1r and F_2 populations of the crosses Master × Perfection 57, Master × Prism and Master × Twin are presented in Table 2.

Table 2. Distribution, mean and variance of plant length (cm) for the parental, F_1, F_1r and F_2 populations of some garden pea crosses.

Population	Frequency of plant length (cm) in class[z]										Total No. of plants	Mean $\bar{X} \pm S_{\bar{X}}$ [y]	Variance (δ^2)
	14	25	36	47	58	69	80	91	102	113			
Master × Perfection 57													
Master (P_1)		12	17	1							30	31.97 ± 1.12 **	37.413
Perfection 57 (P_2)				7	6	8	9				30	64.97 ± 2.33	162.585
F_1				3	4	14	5	4			30	70.10 ± 2.26 NS	153.128
F_1r				2	5	11	9	1	2		30	71.93 ± 2.41	174.685
F_2	2	11	24	30	26	29	35	14	10	1	182	62.05 ± 1.62	476.202
Master × Prism													
Master (P_1)		12	17	1							30	31.97 ± 1.12 **	37.413
Prism (P_2)			8	15	6	1					30	47.00 ± 1.58	75.103
F_1					2	7	14	5	2		30	79.27 ± 1.97 NS	116.271
F_1r					4	12	7	3	3	1	30	77.07 ± 2.63	208.064
F_2	5	22	28	31	26	26	15	5	1		159	51.22 ± 1.56	388.730
Master × Twin													
Master (P_1)		12	17	1							30	31.97 ± 1.12 **	37.413
Twin (P_2)				7	13	5	5				30	60.93 ± 2.04	124.616
F_1					4	9	13	4			30	75.23 ± 1.80 NS	97.495
F_1r				1	4	10	10	5			30	74.13 ± 2.09	131.292
F_2	2	18	19	18	33	19	26	9	3	1	148	55.34 ± 2.24	742.804

[z] Each class represents a range of 11 cm and class values indicated represent class centers.

[y] Pairs of means were either highly significantly (**), significantly (*), or not significantly (NS) different from each other according to (t) test.

In all crosses, parents were distinctively different in plant length as shown in Table 2. Means of F_1's were higher than their respective parents. Mean of F_2 was higher than their respective parents in the cross Master × Prism, meanwhile, in the crosses Master × Perfection 57 and Master × Twin, means of F_2's were intermediate between their parents. F_2 plants of each cross were widely distributed between its two parents with transgressive segregations over the highest parent in all crosses.

No significant differences were observed between F_1's and their reciprocals for plant length in all crosses indicating absence of maternal effect. These results typically agree with those of Noser (2002) and Hamed (2005).

Quantitative genetic parameters obtained for plant length are presented in Table 3.

Table 3. Quantitative genetic parameters obtained for some characters in some garden pea crosses.

Cross \ Parameter	Potence ratio (P)	Better-parent heterosis (%)	Minimum number of genes (MNG)	Broad sense heritability (BSH%)
		Plant length		
Master × Perfection 57	1.31	7.90	0.44	79.49
Master × Prism	5.29	68.65	0.67	82.28
Master × Twin	1.99	23.47	0.16	89.65
		Number of branches/plant		
Master × Perfection 57	4.40	100.00	8.71	75.14
Master × Prism	3.34	64.86	0.50	80.13
Master × Twin	1.40	15.79	2.82	83.69
		Green pod yield/plant		
Master × Perfection 57	6.70	160.48	2.35	79.44
Master × Twin	4.10	118.29	1.10	90.81
		Number of pods/plant		
Master × Perfection 57	4.90	130.37	3.97	79.18
Master × Prism	5.59	148.18	5.70	77.30
Master × Twin	2.58	65.94	2.61	79.91
		Pod weight		
Master × Perfection 57	-0.89	-35.54	5.29	30.75
Master × Prism	-0.02	-22.00	2.53	59.07
Master × Twin	0.04	-19.46	3.35	53.43

Positive P value indicated over dominance of the high parent in the crosses Master × Prism and Master × Twin, and complete dominance of the high parent in the cross Master × Perfection 57. These results are in partially agreement with those of Noser (2002), Hamed (2005) and Sood and Kalia (2006), they found dominance towards high parent in some crosses of peas.

All the three studied crosses exhibited positive high-parent heterosis for plant length trait ranged from 7.90% to 68.65%, with the cross Master × Prism which had the highest value. These results agree with those of Noser (2002) who found positive heterosis values for this character.

Plant length was found to be controlled by one pair of genes in all three studied crosses. These results are in partially agreement with the previous results which reported that this character was controlled by 1-5 genes (Noser, 2002) and 1-3 pairs of genes (Hamed, 2005).

Estimates of BSH% for plant length were high, which ranges between 79.49% and 89.65% (Table 3). These results agree with estimates of Bora *et al*. (2009), Kumari *et al*. (2009) and Galal (2014), they found that it was high.

Number of branches/plant

Data obtained regarding number of branches/plant of parental, F_1, F_1r and F_2 populations of the crosses Master × Perfection 57, Master × Prism and Master × Twin are presented in Table 4.

Table 4. Distribution, mean and variance of branches number /plant for the parental, F_1, F_1r and F_2 populations of some garden pea crosses.

Population	Frequency of branches number/plant in class[z]							Total No. of plants	Mean $\bar{X} \pm S_{\bar{x}}$ [y]	Variance (δ^2)
	1	2	3	4	5	6	7			
				Master × Perfection 57						
Master (P_1)	27	3						30	1.10 ± 0.06 **	0.093
Perfection 57 (P_2)		14	12	4				30	2.67 ± 0.13	0.506
F_1			2	7	6	9	6	30	5.33 ± 0.23 NS	1.540
F_1r			4	3	15	8		30	4.90 ± 0.18	0.921
F_2	28	57	60	18	12	3	3	182	2.71 ± 0.10	1.677
				Master × Prism						
Master (P_1)	27	3						30	1.10 ± 0.06 **	0.093
Prism (P_2)	1	16	11	2				30	2.47 ± 0.12	0.464
F_1			7	15	7	1		30	4.07 ± 0.14 NS	0.616
F_1r		4	8	8	8	2		30	3.87 ± 0.21	1.361
F_2	20	43	54	26	12	3	1	159	2.47 ± 0.10	1.503
				Master × Twin						
Master (P_1)	27	3						30	1.10 ± 0.06 **	0.093
Twin (P_2)				4	20	6		30	5.07 ± 0.11	0.340
F_1				5	6	7	12	30	5.87 ± 0.21 NS	1.292
F_1r				1	8	18	3	30	5.77 ± 0.12	0.461
F_2	35	52	34	13	5	4	5	148	2.55 ± 0.12	2.113

[z] Each class represents a range of a branch and class values indicated represent class centers.

[y] Pairs of means were either highly significantly (**), significantly (*), or not significantly (NS) different from each other according to (t) test.

In the all crosses, the parents were distinctively different in number of branches/plant trait. Means of F_1's were higher than the high parent in all the three crosses. Means of F_2's were higher than their respective parents in the crosses Master × Perfection 57 and Master × Prism, meanwhile, in the cross Master × Twin, mean of F_2 was intermediate between their parents. F_2 plants of each cross were widely distributed between its two parents with transgressive segregations over the highest parent in all studied crosses.

No significant differences were obtained between F_1's and their reciprocals for this trait in the studied crosses indicating absence of maternal effect. These results agree with those of Noser (2002) who reported that maternal effect was not observed in any of the studied crosses. This could be due to nature of self pollination in pea.

Quantitative genetic parameters obtained for number of branches/plant are presented in Table 3.

It is obvious from Table 4 that, high positive P values indicating over dominance towards high parent were found in all the three crosses. These results partially agree with the results of Noser (2002) and Singh and Mishra (2002) who indicated the presence of over dominance and complete dominance towards the highest parent for this trait.

Data obtained on heterosis indicated that all evaluated crosses exhibited high positive heterosis values and ranged from 15.79% to 100.00%. These results typically agree with the results of Noser (2002).

Minimum number of genes controlling number of branches/plant trait was estimated as a single pair in the cross Master × Prism, three pairs of genes in the cross Master × Twin, and nine pairs in the cross Master × Perfection 57. These results partially agree with those obtained by Noser (2002) who estimated it as 1-3 pairs of genes.

Broad sense heritability (BSH) estimated for number of branches/plant was high and ranged from 75.14% to 83.69% as shown in Table 3. These results agree with that obtained by Gupta *et al.* (2006) and Singh (2010).

Green pod yield/plant

Data obtained on green pod yield/plant trait of the parental, F_1, F_1r and F_2 populations of the crosses Master × Perfection 57 and Master × Twin are presented in Table 5.

Table 5. Distribution, mean and variance of green pod yield/plant (g) for the parental, F_1, F_1r and F_2 populations of some garden pea crosses.

Population	Frequency of green yield/plant (g) in class[z]											Total No. of plants	Mean $X \pm S_X$ [y]	Variance (δ^2)
	30.0	62.1	94.2	126.3	158.4	190.5	222.6	254.7	286.8	318.9	351.0			
	Master × Perfection 57													
Master (P_1)	28	1	1									30	33.21 ± 2.36 } **	166.998
Perfection 57 (P_2)	5	11	10	4								30	76.01 ± 5.48	901.313
F_1					13	7	4	3	2	1		30	197.99 ± 8.53 } NS	2180.442
F_1r				2	1	7	10	8	2			30	219.39 ±7.28	1588.253
F_2	87	43	24	12	4	4	3	2		3		182	69.15 ± 4.29	3354.291
	Master × Twin													
Master (P_1)	28	1	1									30	33.21 ± 2.36 } **	166.998
Twin (P_2)			1	18	8	3						30	140.21 ± 4.27	545.999
F_1							3	4	7	4	12	30	306.06 ± 8.23 } NS	2032.395
F_1r						1	1	2	9	8	9	30	307.13 ± 7.46	1668.790
F_2	46	31	26	13	12	3	4	5	2	4	2	148	98.54 ± 6.47	6205.573

[z] Each class represents a range of 32.1 g and class values indicated represent class centers.

[y] Pairs of means were either highly significantly (**), significantly (*), or not significantly (NS) different from each other according to (t) test.

It is notice from the data in Table 5 that, F_1's means were higher than the high parent in the two studied crosses, meanwhile, F_2 means were intermediate between their respective parents. F_2 plants of each cross were widely distributed between their parents with transgressive segregation over the highest parent in the two crosses.

No significant differences were observed between F_1's and their reciprocals for this character in the two crosses. These results partially agree with the findings of Noser (2002) who indicated that maternal effects were remarked in only 2 out of 6 crosses of garden peas.

Quantitative genetic parameters obtained for green pod yield/plant are presented in Table 3.

High positive P values (potence %) indicating over dominance towards high yielding parent were found in the two studied crosses. These results were partially in agreement with that obtained by Sood and Kalia (2006), they found over dominance and partial dominance towards the high yielding parent in pea.

Positive high-parent heterosis values were estimated for the two studied crosses estimated as 118.29% and 160.48% in the crosses Master × Twin and Master × Perfection 57, respectively. These results agree with those obtained by Noser (2002).

Minimum number of genes controlling green pod yield/plant as shown in Table 3 was estimated as 2 pairs in the cross Master × Twin and 3 pairs in the cross Master × Perfection 57. These results disagree with previous results of Noser (2002) who estimated it as one pair of genes. These different results could be due to using different genotypes or different environmental conditions.

Estimates of broad sense heritability (BSH) for this character estimated as 79.44% and 90.81% in the crosses Master × Perfection 57 and Master × Twin, respectively. These results were in agreement with that estimated by Bora *et al.* (2009), Choudhary *et al.* (2010), Singh (2010) and El-Dakkak *et al*. (2014), they estimated high BSH for this trait.

Number of pods/plant

Data obtained regarding number of pods/plant of the parental, F_1, F_1r and F_2 populations of the crosses Master × Perfection 57, Master × Prism and Master × Twin are presented in Table 6.

Table 6. Distribution, mean, and variance of pods number/plant for the parental, F_1, F_1r, and F_2 populations of some garden pea crosses.

Population	Frequency of pods number/plant in class[z]										Total No. of plants	Mean $\bar{X} \pm S_{\bar{X}}$ [y]	Variance (δ^2)
	6	17	28	39	50	61	72	83	94	105			
	Master × Perfection 57												
Master (P_1)	26	4									30	7.47 ± 0.69 } **	14.464
Perfection 57 (P_2)		18	9	3							30	22.50 ± 1.37	56.328
F_1				14	6	4	4	1	1		30	51.83 ± 2.84 } NS	242.695
F_1r			5	9	8	4	3	1			30	47.80 ± 2.71	220.303
F_2	62	52	28	23	7	6	3	1			182	21.71 ± 1.24	279.819
	Master × Prism												
Master (P_1)	26	4									30	7.47 ± 0.69 } **	14.464
Prism (P_2)		22	5	3							30	21.03 ± 1.34	54.102
F_1				13	6	5	4	2			30	52.20 ± 2.66 } NS	211.959
F_1r				16	5	3	2	2		2	30	52.57 ± 3.60	389.564
F_2	60	44	23	18	10	3		1			159	20.23 ± 1.23	242.085
	Master × Twin												
Master (P_1)	26	4									30	7.47 ± 0.69 } **	14.464
Twin (P_2)			1	13	13	3					30	45.60 ± 1.45	63.421
F_1					2	5	12	5	4	2	30	75.67 ± 2.60 } NS	203.057
F_1r				2	1	6	9	5	4	3	30	74.93 ± 3.21	308.202
F_2	56	41	28	10	5	5	1	1	1		148	20.34 ± 1.39	284.241

[z] Each class represents a range of 11 pods and class values indicated represent class centers.

[y] Pairs of means were either highly significantly (**), significantly (*), or not significantly (NS) different from each other according to (t) test.

In the all crosses, the parents were distinctively different in number of pods/plant. Means of F_1's were higher than the high parent, meanwhile, means of F_2's were intermediate between their parents in the all three crosses. F_2 plants of each cross were widely distributed between its two parents with transgressive segregations over the highest parent.

No significant differences were obtained between F_1's and their reciprocals for this trait in the studied crosses indicating absence of maternal effect. These results partially agree with those of Noser (2002) who reported that maternal effect was not observed in any of the studied crosses. This could be due to nature of self pollination in peas.

Quantitative genetic parameters obtained for pods number/plant are presented in Table 3.

High positive P values indicating over dominance towards high parent were found in the all studied crosses. These results typically agree with the results of Sood and Kalia (2006).

Data obtained on heterosis as shown in Table 3 indicated that, all the evaluated crosses exhibited high positive heterosis values and ranged from 65.94% to 148.18%. These results typically agree with the results of Noser (2002).

Minimum number of genes controlling number of pods/plant trait was estimated as three pairs in the cross Master × Twin, four pairs of genes in the cross Master × Perfection 57 and six pairs in the cross Master × Prism. These results were similar with those obtained by Hamed (2005) who estimated it as 1-7 pairs of genes.

Broad sense heritability (BSH) estimated for number of pods/plant was high and ranged from 77.30% to 79.91%. These results indicating good scope for selection on number of pods/plant trait. These results agree with that obtained by Noser (2002), Hamed (2005), Zayed *et al*. (2005), Kumari *et al*. (2009), Choudhary *et al*. (2010), Singh *et al.* (2012), El-Dakkak *et al*. (2014) and Galal (2014). Therefore, selection programme based on this character would be more effective in improving yield of garden peas.

Pod weight

Data obtained on pod weight of parental, F_1, F_1r and F_2 populations of the crosses Master × Perfection 57, Master × Prism and Master × Twin are presented in Table 7.

Table 7. Distribution, mean and variance of pod weight (g) for the parental, F_1, F_1r and F_2 populations of some garden pea crosses.

Population	Frequency of pod weight (g) in class[z]										Total No. of plants	Mean $\bar{X} \pm S_{\bar{X}}$ [y]	Variance (δ^2)
	1.3	2.2	3.1	4.0	4.9	5.8	6.7	7.6	8.5	9.4			
Master × Perfection 57													
Master (P_1)					3	4	8	9	4	2	30	7.09 ± 0.22 **	1.491
Perfection 57 (P_2)			9	8	6	4	3				30	4.42 ± 0.22	1.438
F_1			6	7	9	8					30	4.57 ± 0.18 NS	0.977
F_1r			5	10	11	3	1				30	4.45 ± 0.17	0.824
F_2	6	22	46	50	27	23	6	1		1	182	3.97 ± 0.10	1.847
Master × Prism													
Master (P_1)					3	4	8	9	4	2	30	7.09 ± 0.22 **	1.491
Prism (P_2)			9	13	6	2					30	4.03 ± 0.15	0.642
F_1				5	7	12	4	2			30	5.53 ± 0.18 NS	1.014
F_1r			5	5	5	5	6	4			30	5.32 ± 0.28	2.331
F_2	2	7	14	29	27	40	24	13	2	1	159	5.21 ± 0.12	1.555
Master × Twin													
Master (P_1)					3	4	8	9	4	2	30	7.09 ± 0.22 **	1.491
Twin (P_2)			7	10	12	1					30	4.21 ± 0.14	0.597
F_1				4	10	6	5	5			30	5.71 ± 0.22 NS	1.416
F_1r			2	2	8	13	3	1	1		30	5.50 ± 0.21	1.303
F_2		1	5	12	24	33	31	26	10	6	148	6.23 ± 0.13	2.319

[z] Each class represents a range of 0.9 g and class values indicated represent class centers.

[y] Pairs of means were either highly significantly (**), significantly (*), or not significantly (NS) different from each other according to (t) test.

In the all crosses, parents were distinctively different in pod weight trait. F_1 and F_2 means were intermediate between their respective parents except in the cross Master × Perfection 57 where its F_2 mean was lower than the low parent.

No significant differences were observed between F_1's and their reciprocals for this character in the all studied crosses indicating no maternal effect. These results agree with those of Hamed (2005).

Quantitative genetic parameters obtained for pod weight are presented in Table 3.

Different types of dominance were observed for this character. Positive P values (potence %) were estimated indicating partial dominance towards the highest pod weight in the cross Master × Twin, however, negative P values were observed indicating complete and partial dominance towards the lowest parent in the crosses Master × Perfection 57 and Master × Prism, respectively. These results partially agree with the results of Hamed (2005) who found partial dominance of the lowest parent for this character.

Negative heterosis values for pod weight were estimated for the all studied crosses ranged from -35.54% to -19.46%. These results agree with the results of Hamed (2005) who found negative heterosis values for this trait.

Minimum number of genes controlling pod weight trait was estimated as three pairs in the cross Master × Prism, four pairs of genes in the cross Master × Twin and six pairs in the cross Master × Perfection 57. These results were in agreement with the results of Hamed (2005) who estimated number of genes controlling this character as 3-5 pairs and confirm the polygenic inheritance of this character.

Estimates of broad sense heritability (BSH) were low to moderate and ranged from 30.75% to 59.07%. These results confirm the interaction between environmental conditions and genetic constituents for this trait. These results disagree with that estimated by Bora *et al.* (2009) who estimated high BSH for this trait. Meanwhile, Gupta *et al.* (2006) and Galal (2014) estimated it as 74.65% and 75.0% to 80.0%, respectively. On the contrary, Hamed (2005) found low BSH being 17.6% to 22.6% for this trait.

CONCLUSION

It's clear from the previous results that there are some traits, *viz,* plant length and green pod yield/plant are controlled by one to few numbers of genes and had moderate to high heritability, so the selection for these traits is preferred in the early generations. On the other hand, number of branches/plant and pod weight traits had polygenic effect and its low to moderate heritability, so the selection for these traits is suggested to be done in the late generations.

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دراسات وراثيه على بعض الصفات الكمية فى البسلة
١-وراثة الصفات الخضرية والمحصول ومكوناتة

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أجريت هذه الدراسة بمعهد بحوث البساتين خلال الفترة من ٢٠١٢ إلى ٢٠١٥ و ذلك بهدف دراسة وراثة بعض الصفات الاقتصادية في البسلة الخضراء مثل طول النبات ، وعدد الأفرع بالنبات ، والمحصول الأخضر للنبات ، وعدد القرون بالنبات ، ووزن القرن. إستخدم فى الدراسة ٤ أصناف من البسلة الخضراء هم ماستر ، وبريفكشن ٥٧ ، وبريسم ، وتوين. درست وراثة بعض الصفات الاقتصادية في عشائر كل من الآباء والجيل الأول والجيل الأول العكسي والجيل الثاني لكل من الهجن ماستر × بريفكشن ٥٧ ، ماستر × بريسم ، ماستر × توين. وقد أوضحت النتائج عدم وجود تأثير للأم فى كل الصفات المدروسة. وجدت سيادة فائقة لعدد الأفرع الأعلى ، والمحصول الأخضر العالى ، وعدد القرون الأعلى/النبات فى كل الهجن المدروسة ، بينما وجدت سيادة فائقة أو تامة للنباتات الطويلة ، ووجدت سيادة لوزن القرون الأعلى فى بعض الهجن بينما وجد العكس فى بعض الهجن الأخرى. أعطت صفات طول النبات ، وعدد الأفرع بالنبات ، والمحصول الأخضر للنبات ، وعدد القرون بالنبات تفوقا موجبا مقارنة بالأب الأعلى فى جميع الهجن المدروسة ، بينما أعطت صفة وزن القرون قوة هجين سالبة فى كل الهجن المدروسة. قدر عدد الجينات المتحكمة فى الصفات المدروسة بجين واحد فقط لصفة طول النبات ، و١-٩ لصفة عدد الأفرع بالنبات ، و٢-٣ لصفة المحصول الأخضر ، و ٣-٦ لصفتى عدد القرون بالنبات ووزن القرن. قدرت درجة التوريث على النطاق العريض فكانت ٧٩.٤٩٪-٨٩.٦٥٪ لصفة طول النبات ، ٧٥.١٤٪-٨٣.٦٩٪ لصفة عدد الأفرع بالنبات ، ٧٩.٤٤٪-٩٠.٨١٪ لصفة المحصول الأخضر للنبات ، ٧٧.٣٠٪-٧٩.٩١٪ لصفة عدد القرون/النبات ، ٣٠.٧٥٪-٥٣.٤٣٪ لصفة وزن القرن.

ومن البيانات السابقة يتضح أن هناك بعض الصفات التى يتحكم فيها عدد قليل من الجينات ودرجة توريثها متوسطة إلى عالية مثل صفات طول النبات والمحصول الأخضر وبالتالى يمكن إجراء الإنتخاب لهذة الصفات فى الأجيال المبكرة أما صفتى عدد الأفرع بالنبات ووزن القرن فيتحكم فيهما عدد كبير من الجينات ودرجة توريثهما منخفضة إلى متوسطة وبالتالى يفضل تأخير الإنتخاب لهما للأجيال المتأخرة.